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ABSTRACT

Today, on the eve of the 21st century, Japan is becoming an internationalized, information centered civilization. The sophistication of modern science and technology will create a demand for people who are highly productive in handling knowledge and sensitive in their manipulation of it. This advance of science and technology will also require an examination of life styles and the recovery of human dignity. The purpose of this report is to describe and discuss the characteristics of school science curriculum, which is now under revision in Japan, with relation to the science-technology-society (STS) theme. The present status of school science curriculum is examined in terms of its aims and objectives, scope and sequence, time allocation for teaching, and attained curriculum based on student assessment. After strengths and weaknesses of the present school science curriculum are assessed, and future needs identified, the major trends in reforming the school science curriculum at elementary and secondary school levels are described and analyzed in terms of the inclusion of the STS theme within the curriculum. (CW)

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REFORM OF SCHOOL SCIENCE CURRICULUM FOR THE 21ST CENTURY: SCIENCE-TECHNOLOGY-SOCIETY THEME IN JAPANESE CONTEXT

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Introduction

Japan is now engaged in a major education reform movement. The "first educational reform", which took place in the Meiji era (1872), was intended to contribute to the development of the national state and modern industry. Since the establishment of a modern national state in this era, one of the goals of Japan was to catch up with the industrialized nations in Europe and North America. Through the "second educational reform" after World War II (1947), whose basic guiding principles were the total development of personality, regard for the dignity of the individual, and equal opportunity, the "catching up" educational policy was complemented. In the last four decades, Japan has attained remarkable rapid growth and succeeded in transforming society into an economically and industrially developed country. Japan's education has become a driving force for the development of the nation.(1)

Today, on the eve of the 21st century, Japan is facing a turning point -- transition in becoming an internationalized society, an information-centered civilization, and developing an "80-year-career" lifestyle. The sophistication of modern science and technology, particularly progress in the field of information technology, will create a demand for people who are

highly productive and creative in handling knowledge and sensitive in their manipulation of it. On the other hand, the development of science and technology may have brought about problems such as the spread of materialistic ideas, the absence of feeling, less contact with nature and a lack of regard for the dignity of life. The further advance of science and technology in the 21st century will require a re-examination of our way of living and the recovery of human dignity. Education, and, subsequently, science education, are strongly expected to respond to these needs for the new age.[2][3]

The purpose of this report is to describe and discuss the characteristics of school science curriculum, which is now under revision in Japan, with relation to the science-technology-society (S-T-S) theme. This purpose is attained by first examining the present status of school science curriculum in terms of its aims and objectives, scope and sequence, time allocation for teaching, and attained curriculum based on student assessment. After strengths and weaknesses of present school science curriculum are assessed, and future needs identified, then the major trends in reforming the school science curriculum at elementary and secondary school levels are described and analyzed in terms of the inclusion of the science-technology-society theme into the curriculum.

I. Present Status of the School Science Curriculum

The curriculum is embodied to several needs derived from natural, cultural, and societal conditions, tradition and philosophy in education, nature and contents of academic discipline, growth and development of learner, etc. In Japan, since 1947 when the current democratic educational system was established, several revisions of the national course of studies for elementary, lower secondary, and upper secondary schools have been conducted by the Ministry of Education, Science and Culture. During this period, three major characteristics of school science curriculum can be seen. They are: experience-centered curriculum (1947-1960), discipline-centered curriculum (1960-1980), and human-centered curriculum (1980-present).

In the experience-centered curriculum (1947-1960), life-managing and problem-solving in relation to daily life were emphasized in order to improve daily life and society after World War II. Later on, the decline of achievement levels in students were discussed. Systematic approaches, structure of discipline, and process of inquiry were emphasized in the following discipline-centered curriculum (1960-1980). Due to the large quantity and high quality of academic discipline, depression of learning was discussed. In the present human-centered curriculum (1980-), the development of young people as complete individuals with cognitive, affective, and psychomotor skills harmoniously and fully integrated is emphasized more.(4)

In this chapter, the present status of school science curriculum is described and analyzed in terms of its aims and objectives, scope and sequence, time allocation for teaching, and attained curriculum based on student assessment. Strengths and weaknesses of these characteristics are discussed.

A. Aims and Objectives of Present School Science Curriculum

The present overall objectives of science education in Japan are stated in the "Course of Study for Elementary Schools (1980)," "Course of Study for Lower Secondary Schools (1981)," and "Course of Study for Upper Secondary Schools" (1982).

Overall objective of elementary school science: To develop students' abilities in and attitudes toward making inquiries about nature through observations and experiments, as well as to enhance the understanding of natural things and phenomena, thereby nurturing a rich sensitivity to love nature.(5)

Overall objective of lower secondary school science: To develop students' abilities in (and positive attitudes toward) making inquiries about nature through observations and experiments, as well as to enhance the understanding of matter and phenomena in nature. Thus, to have students realize the relationship between nature and human beings.(6)

Overall objective of upper secondary school science: To develop students' abilities and positive attitudes, to inquire about nature through observations and experiments, to enhance their understanding of fundamental concepts of matter and phenomena in nature, and to develop a scientific view of nature.(7)

These overall objectives for science education in Japan are categorized into four main objectives: knowledge and understanding, scientific thinking skills, observation and experiment skills, and interest and attitude toward nature. There seems to be an emphasis on positive attitudes toward the natural environment. An attempt is made to develop an appreciation, love, and respect for life, and realization of the influence of the natural environment on humans in Japan.(8) However, in order to develop an informed citizenry which can make prudent decisions on scientific/technological issues, application of knowledge and skills into daily life and society seems to be less emphasized in the present school science curriculum.

B. Scope and Sequence of Present School Science Curriculum

In Japanese schools, science is taught to all students at each grade level from kindergarten through twelfth grade. The scope and sequence of the science curriculum are evidenced clearly in the present national course of studies. At the kindergarten level, which is not compulsory, science as a subject is not part of the curriculum, but would appear in a very elementary way, emphasized in the activities oriented within the areas of health and nature.

At the elementary school level (1-6), science is taught as a general science for all students. From the third grade this

general science is divided into three subparts which are "Living Things and Their Environment (A part)", "Matter and Energy (B part)", and "The Earth and the Universe (C part)."

At the lower secondary school level (7-9), science is taught as combined sciences for all students. The "Matter and Energy" part in elementary school science becomes a more in-depth study in one of the combined sciences called "first field" which is the physical and chemical area. The "Living Things and Their Environment" and "The Earth and the Universe", both taught in elementary school science, are studied further in the other of the combined sciences called "second field" which is the biology and earth science area. These two fields are usually taught reciprocally according to the seasons or at the same time.

At the upper secondary level (10-12), which is post-compulsory, the contents of science are divided into six subjects: Science I, Science II, Physics, Chemistry, Biology, and Earth Science. Science I is a required subject for all students in the tenth grade, and is taught as an integrated science which covers basic academic discipline contents such as "Force and Energy," "Construction of Substances and Their Changes," "Evolution," "Balance of the Natural World," and "Man and Nature." Science II and other separated disciplines are elective subjects at the eleventh and twelfth grades. Among these five elective subjects, two or more subjects are required. As a matter of fact, all students study science, at least one subject, each year in the upper secondary school.(9) Among elective subjects, Chemistry, Physics, and Biology are widely studied, while very few students take Science II.(10)

Through the elementary and secondary school years, basic and fundamental concepts in science seem to be intended to be taught. Even at the upper secondary school, basic academic discipline contents are emphasized. Issues on the relationships between humans and nature can be seen in the second field of combined science in the ninth grade, and Science I (integrated science) in the tenth grade. In the final section of the second field at lower secondary school level "Human Beings and Nature," (which includes substances and energy sustaining human existence, balance in nature, and preservation of the natural environment) is learned on the basis of fundamental understanding of the natural environment, matters, and phenomena. In the final chapter of Science I at the tenth grade, "Man and Nature," (which includes resources, utilization of solar energy and atomic energy, and preservation of the natural environment) is learned. There seems to be much emphasis on environmental issues, such as the influence of the natural environment on human beings and the influence of human activities on nature. Yet, scientific and technological issues related to daily life and society do not seem to be widely emphasized.

C. Time Allocation for Teaching in Present School Science Curriculum

The time allocation for science teaching in Japanese schools is recommended by the Ministry of Education, Science and

Culture. In the elementary school, the total number of class hours is 68 for the first grade, 70 for the second grade and 105 for the third, fourth, fifth, and sixth grades. Science is taught two periods per week in the first and second grades, and three periods per week in the third through sixth grades, where one period is equal to 45 minutes. Among these teaching hours, about 80% for the lower grades, about 70% for the intermediate grades, and about 60% for the upper grades in elementary school are recommended to be allocated to practical activities and laboratory work. In the lower secondary school, the total number of class hours is 105 for the seventh and eighth grades, and 140 for the ninth grade. Science is taught three periods per week in the seventh and eighth grades, and four periods per week in the ninth grade, where one period is equal to 50 minutes. Among these teaching hours for science, about 30% for seventh grade and about 20% for ninth grade in the lower secondary school are recommended to be allocated to practical activities and laboratory work. In the upper secondary school, the total number of class hours is 140 for Science I, Physics, Chemistry, Biology, and Earth Science. These subjects are taught four periods per week, where the time for one period is 50 minutes. Among these teaching hours for each subject in science, about 15% is recommended to be allocated for practical activities and laboratory work.(11)

These figures show that most of the time for science in elementary school is devoted to practical activities and

laboratory work where the inquiry about nature through the "hands on" activities is emphasized. As the grade level proceeds higher, less emphasis is put on the practical activities and laboratory work. At the secondary school level, science may be taught in a way where the scientific knowledge is transmitted by the teacher and accepted by students through teacher-centered instruction, rather than learning from real natural matters and phenomena through inquiry processes.

D. Attained School Science Curriculum

The intended curriculum is reflected in curriculum guides and course outlines as described and discussed in the previous sections. The implemented curriculum focuses on classroom teaching where the individual teacher interprets and practices the intended curriculum and students are actually exposed to it. Translation of intended curriculum guides into programs for classes actually depends upon each teacher. Thus, their selection of content or pattern of emphasis may not be consistent with those intended and may differ in each classroom. The attained curriculum is what students have learned as a result of experience in the classroom, and is usually measured by tests and questionnaires. In this section, the results of national assessment and international assessment of students are described, analyzed, and discussed in terms of the development of cognitive skills in science.

The national survey on the condition of curriculum implementation was undertaken in order to determine the level of

understanding of the learners about the educational content based on the present Course of Study which was implemented in 1980 in Japan. Science achievement tests, which were paper-pencil types of tests, were administered in 1983 by the Ministry of Education, Science and Culture. The sample was selected from among the seventh, eighth, and ninth grade students of the lower secondary schools in Japan. One percent of the total population of students was taken as a sample (about 16,000 students) from each grade level for this study. The selected data on the results of the national science achievement tests are shown in Table 1.(12)

The percentage of correct responses on total science achievement tests shows 67.4% of the seventh grade, 62.7% of the eighth grade, and 70% of the ninth grade. These results suggest that the achievement levels of students as a whole can be considered as successful. As shown in the percentage of correct responses by objective evaluation points, which are: knowledge/understanding, observation/experiment skills, and scientific thinking, the achievement levels of students on understanding natural things and phenomena and observation and experimental skills seem to show success. However, the achievement related to scientific thinking, which are: controlling variables, combining variables, interrelating variables, and consistency of logical thinking, was found out to be relatively insufficient. These results suggest that it is necessary to improve the students' thinking skills in science by letting them have first hand experience with real objects and

understand the ideas from real things and phenomena through problem solving processes. The development of cognitive skills in science is one of the most important goals of science education in Japan.(13)

The Second International Science Study (SISS), which is being conducted under the support of the International Association for the Evaluation of Educational Achievement (IEA), was undertaken in twenty-two nations during 1983-1985. The national surveys were coordinated by Miyake, M. in Japan. Samples were taken from fifth, ninth, and twelfth grade students. Selected data on the results of core international tests are shown in Table 2.(14)

As shown in the percentage of correct responses by objective evaluation points which are information (knowledge), comprehension (understanding), and application, Japanese students' scores on comprehension and application are relatively higher than the scores on information in each grade level. These results suggest that it might be necessary to balance these three objectives (knowledge, comprehension, and application) simultaneously in science education in Japan.(15)

In the interim report of the Second International Science Study (National Institute of Educational Research in Japan, 1988), the results of international comparison of students' achievements among seventeen countries indicated that Japanese fifth grade and ninth grade students achieved the highest scores among these countries. However, Japanese twelfth grade students

performed lower than students in Hong Kong, England and Wales, Hungary, Singapore, and Sweden.[16] The achievement level of students at elementary and lower secondary school levels seems to show success. The relative insufficiency in achievement at the upper secondary school level might be explained by less emphasis on the practical activities and laboratory work in science classrooms.[17]

II. New Revision of School Science Curriculum

The development of sound and balanced personalities compatible with the changes and developments in society is a major goal in on-going educational reform in Japan. Goals of education for the 21st century are summarized as follows:(18)

1. The nurture of open and generous hearts and minds, strong bodies, and richly creative spirits;
2. The development of competency for self-education, which comprises the will, attitude and ability to learn independently, which is necessary in our changing and developing society;
3. The acquirement of basic essential knowledge and skills necessary for cultivating sound character formation for life and the development of distinctive personality;
4. The deepening of understanding of international society and Japanese tradition and culture, and the development of awareness as Japanese citizens.

In these goals, basic concepts for reform such as individualization, coping with internationalization and the information age are underlined.

In order to attain these educational goals for the 21st century, the structure and content of school curriculum will be improved. At all levels -- elementary, lower secondary, and upper secondary, concentration on instructional content of the essentials will be attempted. At the elementary school level, in particular, emphasis will be placed on enabling children to master the basic skills of reading, writing, and arithmetic and

to develop good social attitudes and aesthetic sensitivities. Some integration of existing subjects will be implemented for the lower grades of elementary school. At the secondary school level, efforts will be made to diversify the contents of what is taught, putting value on the development of distinctive personalities. To this end, the kinds of required and elective subjects will be re-examined.(19)

Teaching methods will be diversified and evaluation practices improved so that students receive instruction appropriate to their individual characteristics and thereby develop sound and balanced personalities. In order to adapt to the spread of information technology and resulting social changes, the utilization of information media in learning activities in elementary and secondary education will be promoted, and thus the students' abilities to understand, select, process, and create information (i.e., "information literacy") will be fostered.(20)

Subsequently, in science education, with special consideration of the advancement of science and technology, resulting social changes, and developmental levels of learners, emphasis will be placed more on the familiarization with nature, observation and experimentation of nature in order to develop problem-solving ability, scientific view and thinking, interest and attitude toward nature through the elementary and secondary school science curriculum. Developing creativity, the ability to think clearly, judgement and power of expression are highly expected. This is the fifth revision for both elementary and

lower secondary school science, and the sixth for upper secondary school science since World War II. The newly revised course of studies for elementary and lower secondary school will be issued in 1988, and for upper secondary school in 1989. The major trends in reform of school science curriculum at each level are described in this chapter.

A. "Environment" at Kindergarten (21)

At the kindergarten level, in an area newly called "Environment," the contents related to contacts with nature and interaction with the surrounding environment will be included. The objectives of this area will be to have pupils familiarize themselves with nature and the surrounding environment, experience the pleasure of contact with them, and develop the basic and essential attitudes toward inquiry and thinking skills, thereby nurturing a rich sensitivity, motivation of expression, and a basis for creativity. In the present curriculum, concrete experience with nature is emphasized in the area of "Nature". In the newly revised curriculum, the daily life experiences related to their surrounding environments will be more emphasized in a broader sense.

B. "Life" at the First and Second Grades of Elementary School (22)

At the first and second grades of elementary school, a new subject called "Life", whose basic idea is that human beings are a part of the social and natural environment, and live in them,

will be introduced. The objectives of this subject will be to have pupils: be interested in the interaction among themselves, in the surrounding society and in nature through concrete activities and experience, to think for themselves and for their lives, and to acquire the custom and skills necessary in their changing lives, thereby nurturing a stable basis for an independent individual. The contents will be selected from the themes related to "me and my society", "me and my nature," and "myself". This new subject is considered to be an integration of existing subjects which are science and social studies in the present course of study for elementary school. In the time allocation for teaching the subject "Life", the total number of class hours will be 102 for the first grade, and 105 for the second grade.

C. General Science at the Third to Sixth Grades of Elementary School (23)(24)

At the third to sixth grades of elementary school, more emphasis will be placed on the development of will and skills of problem-solving through hands-on experience with natural things and phenomena by observation and experiment. The basic framework of this general science for all students will be the same as the present science curriculum. This general science will consist of three subparts which are "Living Things and Their Environment (A Part)", "Matter and Energy (B Part)", and "The Earth and Universe (C Part)". With consideration of relation to the "Life" at lower grade levels, contents will be

selected from natural things and phenomena, and the growth of the human body relating to daily life. The contents related to science in daily life will be included in terms of the application and continuation of learning in daily life situations by spontaneous problem-solving. The time allocation for teaching science will be basically the same as the present. The total number of class hours will be 105 for each of the third, fourth, fifth, and sixth grades.

D. Combined Science at Lower Secondary School (25)(26)

At the lower secondary school levels (7-9), the objectives will be to develop the abilities and attitudes in making inquiries about nature, and the basic concepts of natural science, which are basically the same as the present objectives of science curriculum. However, in order to attain these objectives, more emphasis will be placed on the observation and experimentation of real things and phenomena related to daily life. The basic framework of this combined science will be the same as the present curriculum. This combined science will consist of two fields. They are: "first field" which is the physical and chemical science area, and "second field" which is the biology and earth science area. In the first field, the contents related to the development of science and human life, and content of light will be included with consideration of the advancement of information technology related to daily life. In the second field, the contents of heredity and evolution will be included with consideration of relation to the upper secondary school science.

At the ninth grade, science will be partially selective, where science will be taught for all students three periods per week and, for the students who selected science, an additional one period per week. In this selective science, selected theme studies, field trips and practical works, and application and enrichment of learning experience will be encouraged according to the students' abilities, aptitudes, and interests. This is considered to respond to the needs for the development of individuality and creativity through the diversification of content and methods instruction. In the time allocation for teaching science, the total number of class hours will be 105 for the seventh and eighth grades each, which are the same as the present, while 105 or 140 hours for the ninth grade. Through the lower secondary school years, educational technology including the computer will be encouraged to be used more as an instructional media in relation to the advancement of information technology and diversification of instructional methods.

E. Diversification of Science Subjects at the Upper Secondary School (27)(28)

At the upper secondary school level (10-12), with special emphasis on observation, experiment, and selected theme studies, the objectives will be to develop scientific thinking skills, judgement, and positive attitudes by having students acquire the methods of science through the processes of inquiry about natural things and phenomena. According to the students'

abilities, aptitudes, and their intended careers, elective subjects will be diversified. There will be three major types of science subjects. They are: comprehensive science, applied science, and pure science. A total of thirteen subjects (including new subjects) will be introduced, while there are six subjects in the present science curriculum.

In the "comprehensive science" (four credits) whose objectives will be to develop the comprehensive view and thinking of nature and deepen the understanding of the relationship between humans and the natural envrionment, observation and experiment of selected natural things and phenomena, and investigation of the natural environment will be emphasized. The contents of Comprehensive Science will consist of "Man and Nature" in the present Science I and theme studies such as surveys of the natural environment and studies on historical cases in science in the present Science II. In addition to this, fundamental concepts in science such as change and equilibrium, and universality and diversity, and inquiry methods such as methodology, implementation and report of observation, experiment and surveys will be included.

In the "applied science" (two credits) which will be newly introduced, emphasis will be placed on the relationship among human life, daily life experience, science and technology. The objectives will be to develop scientific views and thinking through the inquiry about scientific phenomena closely related to daily life and the application of science in human life on the basis of physics, chemistry, biology, and earth science,

thereby deepening the understanding of the relationship between scientific and technological development and human life. The contents will be selected from the scientific topics reported through mass-communication by newspaper, TV, etc., which are not included in the present course of study. As new subjects of applied science, Physics IA, Chemistry IA, Biology IA, and Earth Science IA will be introduced from each perspective of science. In Physics IA, the contents related to computer and information technology will be included. (See Appendix II: contents of applied science in newly revised science curriculum of the upper secondary school level.)

In the "pure science", emphasis will be placed on the logical and systematic understanding of basic concepts derived from academic and pure science discipline for the students whose interests or future careers will be in science. As "basic science" subjects (four credits), Physics IB, Chemistry IB, Biology IB, and Earth Science IB will be introduced. Their contents will consist of a part of present Science I and elective subjects. The contents of Physics IB will be "Force and Energy" in Science I and approximately three-fourths of the contents of elective Physics in the present curriculum. The contents of Chemistry IB will be "Constitution of Substances and Their Changes" in Science I and about three-fourths of the contents of elective Chemistry in the present curriculum. The contents of Biology IB will be "Evolution" in Science I and about three- fourths of the contents of elective Biology in the present curriculum. The content of Earth Science IB will be

"Balance of the Natural World" in Science I and about three-fourths of the contents of elective Earth Science in the present curriculum. In addition to the rest of the contents of elective subjects in the present curriculum, more advanced contents will be included in the "advanced science" subjects (two credits), which will be Physics II, Chemistry II, Biology II, and Earth Science II. In the studies of these pure science subjects, more emphasis will be placed on observation, experimentation, and selected theme studies.

Among comprehensive science, applied science (Physics IA, Chemistry IA, Biology IA, and Earth Science IA), and basic science in pure science (Physics IB, Chemistry IB, Biology IB, and Earth Science IB), two or more subjects (four or more credits) will be required. In teaching these science subjects, the use of the computer will be encouraged more as a tool to support the students' positive inquiry activities.

Summary and Conclusion

The purpose of this study is to describe, analyze and discuss the characteristics of the school science curriculum, which is now under revision in Japan, with relation to the science-technology-society (S-T-S) theme.

With regard to the present condition of Japanese society and education, which determines to a large extent the nature of the school science curriculum, the "desolation" in education was discussed. In the last four decades, Japan has attained remarkable rapid growth and succeeded in transforming society into an economically and industrially developed country through its "catching up" education. The educational system has placed emphasis on the efficiency of importing and rapidly disseminating the science and technology, and statutory institutions organized in some advanced countries. As a result, the uniformity and rigidity of the structure and operation of the educational system were adopted.

The phenomena of desolation in education has to do with a number of problems brought about by modern science and technology. Specifically, the development of modern science and technology has brought about the spread of materialistic ideas, the absence of feeling, less contact with nature, and a lack of regard for the dignity of life. Further, Japan is facing the turning point in a civilization shifting from an energy base to an information base. The progress of the sophisticated information society has been giving people fewer opportunities for direct first-hand experience. The further advance of

science and technology in the 21st century will require a re-examination of our way of living and the recovery of human dignity and will create a demand for people who are highly productive and creative in handling knowledge and sensitive in their manipulation of it. Japan is now engaged in a major education reform movement with special considerations on the impact of science and technology on Japanese society and on the growth and development of Japanese children.

The present status of school science curriculum was described and analyzed in terms of its aims and objectives, scope and sequence, time allocation for teaching, and attained curriculum based on student assessment. Since 1947, when the current democratic educational system was established, several revisions of national course of studies for elementary, lower secondary, and upper secondary schools have been conducted by the Ministry of Education, Science and Culture in Japan. In the present human-centered curriculum (1980-), the development of young people as complete individuals with cognitive, affective, and psychomotor skills harmoniously and fully integrated is more emphasized.

The overall objectives for science education in Japan are categorized into four main objectives: knowledge and understanding; scientific thinking skills; observation and experiment skills; and interests and attitudes toward nature. In the acquisition of knowledge, basic and fundamental concepts in science seem to be intended to be taught through the elementary and secondary school years. Even at the upper

secondary school, basic academic discipline contents are emphasized. Issues on the relationship between humans and nature can be seen in the second field of combined science at the ninth grade level and Science I (integrated science) at the tenth grade level. There seems to be much emphasis on the environmental issues such as the influence of the natural environment on human beings and the influence of human activities on nature. Yet, scientific and technological issues related to daily life and society do no seem to be widely emphasized.

In the development of learning skills, most of science time in elementary schools is devoted to the practical activities and laboratory work where the inquiry about nature through the "hands-on" activities is emphasized. As the grade level proceeds higher, less emphasis is placed on practical activities and laboratory work. At the secondary level, it might be that science is taught in a way where scientific knowledge is transmitted by teacher and accepted by students through teacher-centered instruction. This was implied by the results of national assessment and international assessment of students' achievements. It is necessary to improve the students' thinking skills in science by letting them have first-hand experience with real objects and understanding the concepts from real matters and phenomena through problem solving processes.

In the development of value and ideas, there seems to be an emphasis on positive attitudes toward the natural environment. An attempt is made to develop an appreciation, love, and respect

for life and realization of the influence of the natural environment on humans. However, in order to develop an informed citizenry which can make prudent decisions on scientific/ technological issues, application of knowledge and skills into daily life and society seems to be less emphasized in the present school science curriculum.

The major trends in reform of school science curriculum at each level were described. The development of sound and balanced personalities compatible with changes and developments in society is a major goal of on-going educational reform in Japan. Subsequently in science education, the development of creativity, the ability to think clearly, judgement, and power of expression are highly expected. With special consideration of the advance of science and technology, resulting social changes, and the developmental levels of the learner, more emphasis will be placed on the familiarization with nature, observation and experimentation in order to develop problem-solving ability, scientific view and thinking, decision making, interests and attitudes toward nature through the elementary and secondary school science curriculum.

In terms of the scope and sequence of newly revised science curriculum, two major changes can be seen. They are: the integration of existing subjects at the lower grades of elementary school, and the diversification of teaching contents at the upper secondary school levels. At the first and second grades of elementary school, science and social studies in the present curriculum will be integrated into a new subject called

"Life", although science has been taught from the first grade of elementary school since 1941. The basic idea of "Life" is that human beings are a part of the social and natural environment, and that they live in it. The contents will be selected from the themes related to me and my society, me and my nature, and myself.

At the upper secondary school level (10-12), thirteen subjects (including new subjects) will be introduced, while six subjects are provided in the present science curriculum. There will be three major types of science subjects. They are: pure science, comprehensive science, and applied science. In the pure science subjects consisting of basic science subjects and advanced science subjects, emphasis will be placed on the logical and systematic understanding of basic concepts derived from academic and pure science discipline. In the comprehensive science, emphasis will be placed on the comprehensive view and thinking about nature and understanding of the relationship between humans and the natural environment. Fundamental concepts in science and inquiry methods will be the contents in it. In the applied science subjects, which will be newly introduced, emphasis will be placed on the relationship among human life, daily life experience, science and technology. The objectives will be to develop scientific view and thinking through inquiry about scientific phenomena closely related to daily life and the application of science into human life, thereby deepening the understanding of the relationship between scientific and technological development and human life. The

contents will be selected from the scientific topics reported through mass- communication by newspaper, television, etc. which are not included in the present science curriculum.

At the third to sixth grades of elementary school and lower secondary school level (7-9), although the basic framework of each science curriculum will be basically the same as the present, the contents related to science and technology in daily life will be included. The application and continuation of learning in daily life situations by spontaneous problem-solving will be encouraged further.

In teaching science, more emphasis will be placed on direct experience with nature at hand, and daily life experience relating to science and technology through observation, experiment, and selected theme studies. The utilization of information media including the computer will be promoted in learning activities in elementary and secondary schools so that students' abilities to understand, select, process, and create information (i.e., "information literacy") may be fostered.

In this study, inclusion of the science-technology-society (S-T-S) theme in the school science curriculum was examined. Special attention to the impact of science and technology on society and the development of the learner seems to be given widely in the reform of the school science curriculum in Japan. Inclusions in the curriculum of knowledge, skills, and understanding relative to science and technology in a personal/social context can be seen through the elementary and secondary school science curriculum. Especially, at the upper

secondary school level, S-T-S themes such as concepts of science and technology, process of scientific and technological inquiry, and interaction of science, technology, and society, will be embodied to "applied science" subjects, which are newly introduced. For the 21st century, it seems to be very necessary to include in the curriculum of science and technology in the personal and social context. At any level of society, science and technology have influenced social development throughout history. Education, subsequently science education, is strongly expected to develop young people who can adapt to and lead the future global society, where advanced science and technology will be extensively spread.

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APPENDIX I:

Results of National and International Assessment of

Students' Achievement Level in Science

TABLE 1. The Result of National Science Achievement Tests in Japan

- Achievement Scores by Objectives -

Percent Correct (%)	7th	8th	9th
Total Score	67.4	62.7	70.1
OBJECTIVE EVALUATION POINTS			
Knowledge/Understanding	71.1	64.1	68.5
Observation/Experiment Skills	74.6	68.7	75.0
Scientific Thinking	59.7	57.7	70.8

TABLE 2. The Result of Second IEA Science Study in Japan

- International Core Test Scores by Objectives -

Percent Correct (%)	5th	8th	12th *
Total Score	64.3	67.4	69.3
OBJECTIVE EVALUATION POINTS			
Information (Knowledge)	52.3	56.0	66.7
Comprehension (Understanding)	73.9	72.4	68.3
Application	62.7	70.2	70.7

* Average Score in the Total 12th Grade Populations

APPENDIX II:

Contents of Applied Science in Newly Revised Science Curriculum

at the Upper Secondary School Level

APPLIED PHYSICS (Physics IA)

1. Motion in Surroundings

   Effective use of force, mechanism of vehicle, and fluid and motion

2. Phenomena of Sound and Light

   Music instruments, life and sound, properties of light and optical instruments, and rays and optical grass

3. Heat and Energy

   Heat, temperature, and energy, transmittion of heat (air conditioning and insulator), and combustion engines and efficiency

4. Electricity and Information

   Electricity and work, electric devices in home, electricity and transmittion of information, and principles of computer

5. Atomic Energy

   Radioactive matter and radioactivity, radioactive rays and their use, and energy and atomic power generation

6. Experiments and Experimental Methods

APPLIED CHEMISTRY (Chemistry IA)

1. Materials in Surroundings

   Wood, metal, plastic, and ceramics

2. Change of Substances in Surroundings

   Burn, dissolve, rust, rot, and explode

3. Chemistry in Life

   Textiles, food, housing and materials, perfume, dye, medicine, and cosmetic

4. Making Substances

   Resources (mineral, oil, etc.) and chemical industry

5. Chemistry in Environment

   Water, air, soil, preservation of environment

6. Experiments and Experimental Methods

APPLIED BIOLOGY (Biology IA)

1. Characteristics of Man as a Living Thing

   Sex and birth of man, heredity of man (including a hereditary disease), and evolution of man

2. Mechanism of Life Maintenance

   Immunity (including AIDS), aging and life-span, human body and disease (including cancer)

3. Man in Natural World

   Natural environment and man, man in ecosystems, and preservation of the environment and nature

4. Applied Biology

   Biotechnology, improvement of breed, and genetics engineering

5. Human Life and Living Things in Surroundings

   Use of micoorganism, and edible plants and animals

6. Experiments and Experimental Methods

APPLIED EARTH SCIENCE (Earth Science IA)

1. Earth Science in Surroundings

   Natural scenery, surrounding minerals (including gem), earth science at a street corner (buildings), and hot spring and subterranean water

2. Heavenly Body, Weather, and Human Life

   Season and calendar, weather satellite and weather forecast, and standard time and time differences

3. Resources and Human Life

   Energy resources, underground resources, marine resources, and investigation by artificial satellite

4. Natural Power and Natural Calamity

   Volcano and its calamity, earthquake and its calamity, weather and its calamity, and others

5. History of Home Town

   Rivers, lakes and marshes, and geographical features

6. Experiments and Survey Methods